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A SUMMARY OF PITCH MOTH OBSERVATIONS AND CONTROL WORK IN THE NEBRASKA NATIONAL FOREST

By
L. G. Baumhofer
Assistant Entomologist

Forest Insect Field Station
Coeur d'Alene, Idaho
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A SUMMARY OF PITCH MOTH OBSERVATIONS AND CONTROL WORK IN THE NEBRASKA NATIONAL FOREST

INTRODUCTION

Pitch moths of the genus Dioryctria have been present in the pine plantations in the Bessey division of the Nebraska National Forest near Halsey, Nebraska, for at least 12 or 15 years. These insects must have spread into this isolated area from the native stand of ponderosa pine along the Niobrara River some 50 miles to the north. Two species are known to occur in the plantations at the present time, Dioryctria ponderosae Dyar and Dioryctria abietella D. & S. The former is by far the most prevalent and it was roughly estimated in 1932 that from 90 to 95 per cent of the larvae observed were those of D. ponderosae. Until recently it was considered that a species of Pinipestis closely resembling D. ponderosae was also present, and that these two were responsible for most of the damage, but all specimens of these larger moths have now been determined as D. ponderosae. Consequently, as stated in last year's report, all earlier references to Pinipestis sp. should be considered as applying to D. ponderosae. In the native timber of northern Nebraska one or two additional species of pitch moth larvae have been observed but there is no evidence that these have yet found their way into the plantations of the forest.

Some observations were made on the pitch moths between 1925 and 1929, along with the more intensive studies on pine tip moths and their parasites; however, damage was becoming so prevalent that more detailed studies were started in 1930. As a result of this work it was recommended in 1931 that the heavily infested brood trees be eliminated from the Scotch and Austrian pine plantations to reduce the infestation. These two tree

species, constituting about 10 per cent of the plantations, have recently been so severely damaged that they have been eliminated from the planting program.

In this report the different stages and life history of the pitch moths are described briefly - the stages of the two moths can now be distinguished with some accuracy since it has been determined that only the two species are present. The various studies connected with the winter control cutting operations are given in some detail, the records from tree plots are summarized and other experiments and observations on the pitch moths are recorded in this report. In 1932, Mr. D. O. Scott, who worked on the project as a field assistant two years before, spent the latter part of the season on the forest in connection with a thesis problem, under an arrangement of cooperation with the Forest Service and Bureau of Entomology. He assisted with the examination of winter-felled trees and, after the writer left the forest on August 15, checked various pitch moth plots and made additional observations; thus securing data that would not have been obtained otherwise. Scott submitted a report in October, "The Pitch Moth Situation on the Nebraska National Forest", discussing some of the current observations and reviewing part of the older data, most of which is covered in this report.

DIORYCTRIA PONDEROSAE DYAR

Following is a brief discussion of the different stages and observations on the life history of Dioryctria ponderosae Dyar, the pitch moth responsible for practically all of the damage in the plantations.

Egg

The egg is nearly elliptical in outline and approximately round in cross section, tapering slightly toward each end. The size of the few

eggs measured varied from 1 to 1.25 mm. in length by .75 to .87 mm. in diameter, the shape being somewhat irregular in some cases. The egg when laid is white but soon changes to an orange-red color which is retained until the developing larva is visible through the egg shell.

Larva

At the time of hatching the new larva is about 2 mm. long and light brown in color with a darker head. At maturity the larva measures from 21 to 25 mm. (7/8 to 1 inch) in length. The color of the maturing larvae is usually a light brown but occasionally specimens are found with a distinctly greenish tinge. The setiferous tubercles, after the earliest instars, are very conspicuous and appear as a series of dark dots on all the body segments.

Pupa

The pupa is smooth, reddish brown in color and averages about 15 mm. (5/8 inch) in length, varying from 14 to 17 mm. in different specimens.

Adult

The adult is a blackish grey moth with a wing expanse of approximately 30 mm. (nearly 1¼ inches). Different specimens vary in size from 28 to 32 mm. across the wings. The most distinctive markings on the adults are the two narrow, W-shaped bands, grey bordered with black, running across each forewing; one in the basal half of the wing, the other in the outer third. The few tufts of raised scales on these wings are less noticeable but can be found near the base and in the outer half of the wings on fresh specimens. The hind wings are uniformly dusky white.

Life History Notes

Dioryctria ponderosae has a single generation each year. Adults emerge during the period from the third week in July to the first week in September, with the peak of emergence occurring in the second or third week in August. Egg laying probably continues during most of this same period with the last moths continuing to oviposit for possibly another week. The eggs are usually laid singly on the under side of bark scales or in crevices on the bole of the tree, but occasionally groups of 2 or 3 eggs are found. Data on the incubation period are incomplete but it appears that the early eggs hatch within two weeks and the late eggs within three or four weeks after being laid. The new larvae hatching from the few eggs in the laboratory were observed to spin a small hibernaculum or thin cocoon in the bark crevices and it is possible that some of them spend the winter in these hibernacula without feeding. On the other hand, a few larvae of about the second instar have been found in the field in early fall which had either bored into the bark or had been feeding to some extent on the inner bark, and these were assumed to be the same species. It is apparent at least that hibernation occurs in the bark and that the insect goes through the winter in the earliest larval stages. The first evidence of the presence of these larvae is found the following spring when a small amount of frass appears on the bark, and later an exudation of pitch. The larvae feed entirely in the cambium region and as they grow they make irregular burrows of various shapes beneath the bark. Some of these burrows are rounded cavities with a number of short side galleries while others may extend for several inches around the tree. The large pitch masses (see fig.1) are conspicuous in June, however, in cases in which a number of larvae have partially girdled the base of a large limb, the flow of pitch is apparently cut off and there is little external evidence to indicate the number present.

When mature the larva spins a papery, white cocoon in its burrow, or occasionally in the dried pitch mass, and pupates. Pupation occurs during July and early August and the insect remains in the pupal stage for approximately three weeks. The adult moth, when ready to emerge, leaves the pupal skin and forces its way through an exit hole which had been prepared by the larva but left concealed by a flake of bark or webbing over the small hole.

The eggs of this pitch moth were first located in 1930 by placing a cage (see fig. 2) around the heavily infested portion of a tree and permitting the moths to emerge and oviposit in this cage. Before an examination was made a female moth was dissected to determine the general size and shape of the eggs to be looked for. The cage was removed on September 11 and all surfaces of the bark carefully examined with the result that three of the unhatched, red eggs and several empty, white egg shells were found under the bark scales, as well as a newly hatched larva which had apparently started boring into the outer bark. A few eggs were found on other trees after this discovery.

What is presumed to be the normal act of oviposition was noted in this same cage shortly after dark on September 9 and 10, when the last remaining female moth was being observed by Scott and the writer through the cheesecloth sides of the cage with the aid of flash lights. The moth in crawling over the bole of the tree was observed several times to stop over a small bark crevice for 15 or 20 seconds, bend the abdomen down at nearly a right angle and insert the tip of the abdomen. By this process a female could readily place an egg with the ovipositor on the under side of a bark scale.

The adult pitch moths are rarely seen in the field. They seem to

be entirely nocturnal and in the observation cages it was found that no activity occurred until after dark. Last summer Scott noted that mating took place in the early morning before daylight and in one case he observed such activity at 1:40 a.m. It appears that these moths may be active most of the night.

DIORYCTRIA ABIETELLA D. & S.

The life history of Dioryctria abietella has not been completely worked out because of the scarcity of material, however, several stages of the insect are distinguishable from the other species and these will be discussed here briefly with a few notes on other observations.

The adult is a blackish grey moth with a wing expanse of from 21 to 25 mm., superficially resembling D. ponderosa in markings. It differs from D. ponderosae in being slightly smaller, having more pale dusting in the center of the forewings, the W-shaped transverse lines more white, the raised tufts of scales entirely absent, and the hind wings more smoky.

The egg and new larva have not been observed. The larger larva is somewhat reddish in color, often shading from a near pink beneath to a dark color, almost a purple, on the back. The setiferous tubercles are not visible and this distinguishes the larva from that of the larger species. The mature larva attains a length from 19 to 22 mm. The pupa is smooth, reddish brown, resembling the pupa of D. ponderosae except in being smaller, measuring from 10 to 12 mm. in length.

Dioryctria abietella is distributed over most of the pine growing regions of the world and is known to attack the bole, the new growth shoots and the cones of pine. It has been found under all these conditions on pine in Nebraska, including several cones of ponderosa pine, but it is most common under the bark of the bole or larger branches. Adults have been reared throughout the period from June 21 to the first week in September,

a longer emergence period than for D. ponderosae. In one case a maturing larva, collected from a tree on October 6, 1930, was kept in a vial with fresh bark and in early winter was taken into a warm laboratory; the larva pupated and the adult D. abietella emerged on January 7, 1931. It is probable, therefore, that some moths emerge earlier than the June 21 record given above. There appears to be but a single generation annually, from the evidence obtained thus far.

Larvae of various sizes, some nearly mature, have been found under the bark as late as November 11, and it is apparent from this that the insect must spend the winter in the tree in various stages of larval development. Several pupae have been taken in the burrows in June. A habit that seems to be peculiar to the larvae of this species in making an attack at the edge of a pitch moth scar or pruning scar, is the spinning of a light web over the edge of the old wound particularly where the flow of fresh pitch is lacking. However, this webbing is not evident where the attack occurs on a fresh bark surface. A canabalistic tendency has also been noted with these larvae. Where two larvae were placed in the same vial with bark, one was sometimes destroyed and eaten. Scott, in his report, mentions finding two cases last summer where a larva of D. abietella was found feeding on a pupa of D. ponderosae. This canabalistic and predacious tendency should perhaps be considered accidental until more information is obtained.

PITCH MOTH INJURY

The work of a pitch moth larva under the bark causes a pitchy scar which would normally heal over in several years were it not for the fact that this same spot is usually reattacked from year to year, sometimes by a number of larvae, and the wound thus enlarged. A large wound of this

character weakens the bole as the tree increases in diameter and breakage may follow (see fig. 1). The most serious type of injury in the plantations, however, is girdling, which may occur at any point on the main stem of the tree or at the base of the branches. Tops are often girdled as a result of one or two years' work, but a majority of the attacks occur on the main bole where a number of years' work is usually required for complete girdling. The pitch pockets left under healed wounds would probably be an important type of pitch moth injury in saw timber but in the comparatively small trees in the plantations, most of which are still under 8 inches d.b.h., the principal damage is the serious deformation of many trees (see fig. 3) and the occasional killing of a few. the bole of the tree at the whorls is the most favored point of attack. Infested trees apparently are more attractive for oviposition than normal trees, since a large per cent of these same trees are infested annually. Isolated trees and open stands are more susceptible to attack than trees in a dense stand with a closed canopy; however, where the infestation is heavy, attacked trees can be found even in the densest stands. Trees under 2 inches d.b.h. are not particularly susceptible to attack but occasionally these smaller trees are infested.

The tree species most susceptible to pitch moth attack are the two exotic species, Austrian pine and Scotch pine. The per cent of trees infested in different plantations of these species varies from 15 or 20 to 70 or 80 per cent, being heaviest in some of the small groups of older trees where the stand is open or exposed on all sides. Corsican pine is also a host tree, but from the few trees of this species in the forest its susceptibility can not be compared, although the damage has been fairly light. Ponderosa pine is commonly attacked, but injury is far less serious than for the first two species. Jack pine had very little infestation

until recently and damage to this species is still negligible. A few attacks have been found in Norway pine in the last few years.

Some idea of the amount of infestation and breakage in the more susceptible species and in one of the more heavily infested areas can be gained from Table 1. The data are based on an examination in 1931 of three small blocks of trees planted in 1910 and 1911, constituting one of the silvics blocks near camp 1.

Table 1. - Per cent of trees infested by pitch moths and per cent with breakage or dead parts resulting from pitch moth work, in a small silvics block planted in 1910 and 1911, as shown by an examination in 1931.

Species of pine	No. of trees	% showing old or new infestation	% with current attacks	% with dead or broken tops or branches	% with tops or bole girdled or broken
Austrian	109	78	64	60	49
Scotch	206	64	46	43	28
Ponderosa	446	21	9	3	2

The Austrian pine, shown in Table 1, suffered considerably more damage than the Scotch pine, but this is partly attributed to the more open and exposed condition of the stand in this smaller group of trees. In Austrian pine, about 20 per cent of the girdling or breakage of the main stem occurred on the lower two-thirds of the bole, while in Scotch pine, 38 per cent occurred on this portion of the trees, the remainder of the damage being top killing. The denser stand of ponderosa pine, which was immediately adjacent to the Austrian pine, had comparatively little serious infestation and it is evident that this species is much less susceptible. The amount of pitch moth infestation in parts of the native stand of ponderosa pine in northern Nebraska under natural conditions is greater than the present infestation in this species in the plantations.

however, it is not as serious as conditions shown above for the Austrian and Scotch pine plantations. The character of infestation in other plantations in the Nebraska Forest will be discussed later in connection with the tree plot studies.

In ponderosa pine, the Peridermium galls, caused by a rust fungus (probably Peridermium harknessii) are commonly attacked by the larvae of the pitch moth, Dioryctris ponderosae. The larvae not only feed in the outer layers of the swelling, but also bore through the woody part of the gall. With the increased prevalence of this rust, it has been found that in certain plantations more pitch moth attacks are occurring in these galls than on the main part of the trees. The infection is most common on the branches and the gall ususlly girdles the branch in a couple of years. The work of the pitch moth merely hastens this girdling. There has been no opportunity to study the interrelation of the disease and the insect, but it has been suggested by Supervisor Nelson that the larvae, in destroying the remaining surface of the gall, are preventing any subsequent sporulation, in which case the insect would be beneficial in retarding the spread of the disease.

SPRAYING EXPERIMENTS

During the summer of 1932, some preliminary tests were made with a spray as a possible method of destroying pitch moth larvae. The material used was orthodichlorobenzene applied undiluted and also as a mixture of equal parts of orthodichlorobenzene and kerosene. The spray was applied to the bark at the point of attack, as indicated by pitch masses, and immediately surrounding. This work was done during the first half of July when the larvae were nearly full grown and covered 67 attacks on 12 trees of different species, mostly Scotch pine.

Examinations were made of different trees from 4 to 29 days after spraying, and the insects cut out to determine their condition. The only mortality found was where the larvae had been subjected to the applications for 3 or 4 weeks, by which time most of the larvae not effected had pupated. In an Austrian pine examined 21 days after spraying with the mixed solution, 1 dead larva was found as compared to 3 live pupae; in 5 Scotch pine examined 23 days after a similar treatment only 2 larvae were dead, while 18 larvae and pupae remained alive. One Scotch pine sprayed with straight orthodichlorobenzene was left for 29 days before the inspection was made and a 50 per cent mortality was recorded, or 5 dead larvae as compared to 5 live larvae and pupae.

It is evident that the action of orthodichlorobenzene as a fumigant in the bark is very slow. It also seems that this material has some possibilities, but to determine its real value experiments will have to be continued and the examinations for mortality delayed for over a month after the spray is applied. Because of this time element the difference between the straight material and the mixture with half kerosene cannot be analyzed, but it is apparent at least that the mixture was no quicker in its action, and possibly no more effective. As a contact insecticide the mixed solution seemed to have no value because where several larvae were exposed and wetted twice with the spray they were found a few days later to be continuing their work in the pitchy burrows. No injury to the living tissue under the bark was noticeable; however, these trees should be examined next summer for evidence of spray damage to the cambium. Orthodichlorobenzene is injurious to the foliage, and where sprayed on several small branches of ponderosa pine the outer half of the needles was found turning brown after 4 days. If a suitable spray is found it might be used to particular advantage in the

pruned plantations, not only to protect the bole of the trees, but to keep the infestation down.

WINTER CONTROL CUTTING

The first thinning of plantations was started by the Forest Service in the winter of 1929-30 and included some of the oldest Scotch pine planted in 1910. In thinning, most of the heavily infested and deformed pitch moth trees were removed. An examination, the following summer, of logs remaining in the areas disclosed only one case, in a ponderosa pine left in the shade, where larvae were maturing, none being found in Scotch pine trimmed and left in the open; indicating that mortality to young larvae hibernating in the winter-felled trees was very high. This suggested a possible means of control; by felling in winter and exposing or removing the heavily infested brood trees, which are reattacked each year, a great many larvae could be destroyed and one of the main sources of moth production removed for the present.

Thinning was continued on a small scale the following winter and further observations were made in the thinned areas. Although most of the cut material had been disposed of for fuel, a number of small logs remaining were inspected and in only one Scotch pine was evidence of developing larvae found - two being taken from the under side in the wood which had been kept moist by contact with the soil. A check of plots established in the Scotch pine thinned the first year, which had been only moderately infested, showed that the infestation was very light, after elimination of the worst trees, and also that scars left from pruning were not particularly attractive to the moths. Other plots demonstrated that a high per cent of the same trees were reinfested from year to year and that the so-called brood trees were invariably attacked. Thus in cutting the brood trees at a time when no evidence

of the young larvae was apparent it would be almost certain that a considerable number of hibernating larvae were present in these trees.

On the basis of the above information it was definitely recommended in 1931 that the winter control cutting be extended to all the susceptible Scotch and Austrian pine plantations, since this appeared to be the only feasible means available of reducing the infestation which was assuming serious proportions in these trees. Such a program was carried out by the Forest Service in the winter of 1931-32 covering, according to Supervisor Nelson's annual report, a total of 186 acres of established plantations - 140 acres of Scotch pine and 46 acres of Austrian pine. The pitch moth plot studies will show the amount of infestation remaining after the control cutting, but it will not be until next summer that the amount of increase from moths left in the lightly infested trees can be determined.

The cost of the above control cutting operation, as reported by the Forest Service, was $5.85 per acre (all contributed time). The reduction in infestation as a result of this control work is estimated at 50 to 60 per cent, as will be discussed later.

The experiment with mechanical control in 1927, by cutting the larvae out of infested trees, cost $13.00 per acre. However, this was in areas with an infestation above the average. This experiment covered 23 acres of Scotch pine plantations planted in 1913, the stand averaging about 350 trees per acre. Fifty-one per cent of the trees was infested with 6.1 attacks per infested tree, and it was estimated that 88 per cent of the larvae were destroyed. The reduction in infestation the following year, after one flight of moths, was 80 per cent as compared to conditions prior to control.

NUMBER OF TREES CUT FOR CONTROL

Counts were made in two plantations, containing approximately an average amount of infestation, for an estimate of the number of trees removed primarily for pitch moth control. One was an area of Austrian pine, (plantation P-100) planted in 1914, where cutting was limited to control work with few or no trees taken out for thinning improvement. Out of 1,000 trees counted, 145 or 14.5 per cent had been cut. In a plot of 200 trees previously established in one corner of this plantation 10.5 per cent had been removed in the control operation. The original tree survival on this area had been very uneven, consequently many of the brood trees occurred at the edges of openings or were somewhat isolated, however, others occurred in the denser groups of trees and some of these would have been removed from a thinning standpoint.

In the Scotch pine plantation used for similar counts, (P-70-2b) planted in 1913, a thinning and pruning operation had been conducted along with the control cutting, over part of the area. Consequently, the records from a plot of 400 trees were analyzed to determine which trees had been heavily attacked for several years and for this reason had probably been cut as brood trees. The analysis indicated that about 63 trees or 16 per cent were cut because of their infested condition; two-thirds of these trees were either badly forked, had the tops out or large limbs broken as a result of pitch moth work. Besides this 16 per cent, an additional 7.5 per cent of the stand was removed in thinning, these trees having little or no infestation.

These figures, taken from areas with what might be considered an average infestation, would indicate that for the control areas as a whole an average of possibly 15 per cent of the original stands was removed for pitch moth control. In some plantations of small size with an open, exposed stand

and a very heavy infestation this per cent would, of course, be considerably higher, but in some of the more extensive plantings with the stand fairly dense it would be less. Comparing the number of trees cut with the total number infested, the Austrian pine plantation mentioned above showed about a third of the infested trees removed, while the Scotch plantation showed over half of the infested trees cut. This difference is due to the more scattered nature of the attacks in Austrian pine, fewer trees attacked to an extent where they would be considered serious brood trees, while in Scotch pine concentrated attacks seem to be more common. Taking out every tree that showed any signs of infestation would have been too radical a measure. As it was, in some plantations not many more trees were removed than would have been cut in a thinning operation, however, many of these were not located so as to constitute a valid thinning. The detrimental effects of the control operation are mainly the small openings made in the stands, the enlarging of other openings (see fig. 3) and the elimination of isolated trees serving as a partial ground cover. The benefit from the operation is the reduction in number of pitch moths and the resulting protection for the remaining trees.

LARVAL MORTALITY IN WINTER-FELLED TREES

A more complete study of the mortality to pitch moth larvae in winter-felled trees was made possible in 1932 when the Forest Service placed a large number of Scotch pine logs, in a 1913 plantation, under various conditions of exposure and left other trees as they fell for the purpose of summer examinations. There was not enough time to examine all of this material but samples were taken from each situation, sufficient to show that very few of the larvae ever reach maturity but that occasionally moths emerge from felled trees. The examinations were made between August 1 and 10, after most

of the larvae had pupated and a few moths had emerged. In the cases where the few empty pupal skins were found it was often difficult to tell whether they were fresh or old but these were judged largely on the freshness of the frass. A summary of the number of logs or felled trees examined under different conditions of exposure and the insects found, is given in Table 2. These felled trees varied in size from 3.5 to 8.7 inches in diameter on the stump, and the logs, which refers to the trimmed material, were from 8 to 18 feet in length.

Table 2. - Number of live and dead pitch moth larvae and pupae found in winter-felled Scotch pine left under different conditions of exposure and piling, as shown by an examination in early August, 1932.

Exposure and condition of examined material	No. logs examined	No. logs with live insects	No. live insects: Larvae	No. live insects: Pupae	No. dead insects: Larvae	No. dead insects: Pupae
In shade; pile of 12 logs, piled 5 logs high	9	6	1	9	0	2
Partial shade; pile of 7 logs	7	2	0	2	0	0
Partial shade; group of 6 logs on ground	6	3	0	3	1	0
In shade; single trees not trimmed, off ground	7	2	0	2	1	1
In sun; single trees not trimmed, off ground	5	2	0	2	1	3
In sun; pile of 40 logs piled 4 feet high	23	5	4	9	0	0
In sun; pile of 12 logs piled 3 logs high	7	0	0	0	0	0
Total	64	20	32		9	

The only stages of the insect found in the above logs were maturing larvae and pupae; no evidence of the remains of the young larvae, which must have suffered a very heavy mortality, was observed. The number of dead insects indicates that even with those reaching the more advanced stages not all produce moths, over 20 per cent of those found being dead. The number of trees under each condition of exposure is not large enough to predict a per cent of emergence for each situation, but it is apparent that the pile of logs under a dense canopy was most favorable for development. Logs in

contact with the ground and under partial shade had partly favorable moisture conditions on the under side. In the larger pile in the sun the lower logs had a condition somewhat similar to shade but probably with higher temperatures. The individual untrimmed trees left exposed to the sun had previously been heavily infested and must have harbored many overwintering larvae. Portions of these trees were protected somewhat by their foliage until the needles dried and even though a few insects developed as far as the pupal stage over half of these succumbed before the moths could emerge. In no case were live larvae or pupae found on the side of felled trees or logs exposed to the direct rays of the sun. In taking temperature readings with thermometers under bark about a quarter-inch thick, on a log of more than average size in the sun, Scott recorded temperatures as high as 50° C. (122° F.), which would be fatal to any ordinary insect - and these readings were probably not the maximum for the hottest days. It had also been demonstrated in 1930 and 1931, with a few infested trees felled and exposed to the sun in late June, when the larvae were about mature, that no survival occurred on the sides of the tree subjected to direct solar heat. However, these advanced stages usually completed development on the under side of the tree or on the portions of the sides shaded by branches.

In examining the felled trees it was noticed that many of the larvae had burrowed beneath the surface of the wood, some as much as a quarter of an inch, apparently in an attempt to escape dessication. This is not a normal habit since the work is usually confined to the cambium region and at most the wood only slightly scored. Other larvae were found deep in old pitchy wounds. The wood in many of these logs was slightly moist but this was partially attributed to recent rains. A few bark beetles, Orthotomicus and Hylurgops, were found developing on the under side of some of these

Scotch pine logs, particularly those in the shade, indicating that moisture conditions were not entirely unfavorable.

An estimate of the number of larvae hibernating in the felled trees, and the subsequent mortality, can be made from plot data in this same plantation the previous year. Infested trees in 1931 averaged 3.5 larvae per tree, or if only the trees felled later are considered the average was 4.2 per tree. Assuming a small increase for 1932 it would seem conservative to estimate that for the 64 felled trees examined, the average number of insects would normally have been at least 5 per tree, or a total of 320. Only 32 live insects or 10 per cent of this total were found, thus indicating a mortality of 90 per cent. In a control cutting operation, if the trees were not removed but merely left on the ground as felled, it appears that a large majority of the insects would be destroyed with possibly around 10 per cent finally emerging as moths. This small per cent of emergence could be largely eliminated by placing all trees in the open where they would be exposed to the direct rays of the sun and then, after a period of hot weather, turning the trees or logs to expose the under side. This turning operation should be carried out in the later part of June or at least by the first week in July, before many of the remaining larvae had pupated.

PITCH MOTH TREE PLOTS

A number of tree plots were established in 1930 for a study of pitch moth infestation in different species of pine, although counts had been made in one plot of Scotch pine prior to this time. Six of these plots were laid out after the first thinnings in Scotch and Jack pine to determine the character of infestation following thinning and pruning, and these will be discussed separately later. Three other plots, in Scotch, Austrian and ponderosa pine, give an idea of the infestation and number of attacks in comparable plantations of nearly the same age. The Scotch and Austrian pine

plots also serve to show the nature of the epidemic before and after winter control cutting of 1931-32. It will be noted that these plots were enlarged recently for a better sample of conditions following control. Density of stand was not recorded in these plots, but they are somewhat similar in susceptibility.

For comparing the amount of infestation in these plots, containing a variable number of trees, an "Infestation Index" has been worked out for each. This is arrived at by multiplying the per cent of trees infested by the average number of attacks per infested tree times 100; the figure merely showing the total number of attacks for 100 average trees, based on the entire plot.

Scotch Pine

The Scotch pine plantation containing the plot shown in Table 3, (see fig. 4) had been influenced by earlier experimental control work and consequently the infestation recorded in the table is probably somewhat below what might have been found had the area remained untouched. In 1927 a large per cent of the larvae were cut out of the infested trees in this plantation, thus effecting conditions considerably. The original infestation in 1927 amounted to 51 per cent of the trees infested with an average of 6.1 attacks per infested tree. The following year, from progeny of insects missed, 33 per cent of the trees were infested but with only 1.7 attacks per tree. The plot of 200 trees established in one corner of the plantation, using every second or third row to cover variations of stand, will illustrate conditions since 1929; the number of trees being doubled in 1931 before control cutting. It is evident that the infestation had not built up again to its original size, as found in 1927, during the four years following this first experimental control. No measurements were taken on diameter and height of these

trees but in 1930 a few were 6 inches d.b.h. or over, the average probably being between 3 and 4 inches, and average height between 15 and 20 feet.

Table 3. - Plot B-S.P.; showing the amount of pitch moth infestation in a 1913 planting of Scotch pine (No. P-70-2b) from 1929 to 1931, and the infestation remaining in 1932 following winter control cutting, thinning and pruning.

Year	No. trees in plot	% of trees infested	Average no. attacks per infested tree	Infestation index
1929	200	31	3.2	99.2
1930	200	20	2.5	50.0
1931	400	26.5	3.5	92.8
	Infestation remaining after winter control cutting and thinning			
1932	305*	16.1#	2.9	46.7

*(Estimated that out of the original 400 trees 16% cut primarily for pitch moth control and 7.5% additional for thinning; 1 tree broken by wind).

#(Two trees with attacks recorded in Peridermium galls not counted).

The apparent drop in infestation in 1930 can not be fully explained except for the evidence that one of the parasites destroyed a greater number of pupae that year than usual; however, there may have been other influencing factors. The increase in 1931 is not so evident from the per cent of trees attacked as from the total number of attacks, as shown by the "Infestation Index" which indicates an 86 per cent increase over 1930, bringing back a condition similar to 1929. The increased size of the plot in 1931 had little influence since the total attacks in the two parts of the plot were about equal. The effect of control will be discussed under the heading of "Reduction of Infestation from Control Cutting".

Austrian Pine

The plot in Austrian pine shown in Table 4 below, included 100 trees when established, but this number was doubled in 1932, including trees already felled, to provide a greater sample of trees to compare with data next

year. Measurements on the first 100 trees in 1930 showed an average d.b.h. of 2.4 inches for 95 trees, the other 5 trees being less than 4.5 feet in height, and having a maximum diameter of 4.5 inches. The trees averaged about 10 feet in height, with a few near 15 feet.

Table 4. - Plot 2-A.P.; showing amount of pitch moth infestation in 1930 and 1931, in a 1914 planting of Austrian pine (No. P-100), and infestation remaining in 1932 following winter control cutting.

Year	No. trees in plot	% of trees infested	Average number of attacks per infested tree	Infestation index
1930	100	28	2.1	58.8
1931	100	38	4.3	163.4
Trees and infestation remaining after control, in plot enlarged to 200 trees				
1932	179*	22.3	2.3	51.3

*(Of the 200 trees used for this plot in 1932, 10.5% had been cut for control during previous winter).

Similar to the Scotch pine, the infestation in the Austrian pine above, showed a decided increase in 1931. The per cent of increase in number of attacks, from the index figures, was 178 per cent over 1930, or twice the increase shown for the Scotch pine.

Ponderosa Pine

Data from a ponderosa pine plot are presented in Table 5, and again demonstrate that this species is much less susceptible than the previous two species. The attacks in Peridermium galls are considered as secondary and are not included in the plot data. The attacks recorded as primary, occurring on the main stem or base of branches, are comparable to the attacks in Austrian and Scotch pine. This plot was increased by 50 trees in 1932. Although of about the same age, the trees are somewhat smaller than those in the Austrian and Scotch pine plots, as a result of the heavy damage by the pine tip moth. The original 150 trees in 1930 had only 121 measuring over

4.5 feet in height, these averaging 2 inches d.b.h. with a maximum diameter of nearly 4 inches. The average height was approximately 7.6 feet with some trees 13 feet tall. No control cutting occurred in ponderosa pine so this plot has not been disturbed.

Table 5. - Plot 1-P.P.; showing amount of primary infestation on bole and base of branches, by pitch moth in a 1913 planting of ponderosa pine (No. P-72-4c) from 1930 to 1932.

Year	No. of trees in plot	% of trees infested	Average number of attacks per infested tree	Infestation index
1930	150	6.7	2.1	14.1
1931	150	4.0	1.8	7.2
1932	200	10.5	1.9	20.0

The data in Table 5 show a decreased infestation in the ponderosa pine plot in 1931, in contrast to the increase recorded for the other tree species that year. At about this time, in 1930 or 1931, some Peridermium control work was carried out by cutting off the galls in the locality including this plot and it is possible that this work was done in 1930 and a considerable number of larvae were destroyed, thus effecting the 1931 infestation. The actual dates for the gall removal work are not at hand to check the accuracy of this assumption. Furthermore, no counts were made of infested galls in either 1930 or 1931.

In 1932 Scott made an estimate of pitch moth attacks in Peridermium galls in the plot. He recorded 22 trees or 11 per cent thus affected, 4 of the trees having both primary and secondary infestation, and estimated a total of 91 attacks in the galls or 4.1 attacks per tree. This would give an "Infestation Index" of 45.1, or more than twice as many larvae working in the galls as on the main part of the trees. It appears that the attraction to these galls, most of which are out on the branches, is preventing a greater number of attacks on the bole and is serving as a measure of protection.

PLOT ESTABLISHED AFTER THINNING

Following the first thinning and pruning operations in the winter of 1929-30, in the older Scotch and Jack pine, pitch moth plots were established in these areas utilizing the tenth acre silvics plots staked out by the Forest Service. The purpose was to follow the progress of the epidemic in plantations lightly infested as a result of removing brood trees or where little original infestation occurred, and also for a later comparison of conditions in stands of different densities both thinned and unthinned. Another point to be observed was the possibility of the pruning scars being attractive to the moths and drawing insects from the surrounding plantations of different species. This last factor, however, seemed to be of little importance since it was found in 1931, after the progeny from the first flight of moths were evident, that the infestation remained light and out of 42 attacks only 8 or about 20 per cent were at pruning scars.

Scotch Pine

The plots in Scotch pine are in a 1910 planting where the Forest Service estimated from 25 to 30 per cent of the trees infested in parts of the plantation before thinning. Many of the heavily attacked and deformed trees were removed and the data for 1930 indicate the number of larvae overwintering in the remaining trees not effected by control cutting. During a clean-up operation in the winter of 1931-32 a few additional trees were removed, again reducing the infestation. A few Jack pine are mixed in these plots as will be noted, but none of these have been attacked. The loss of a few trees in the plot is due to natural death or breakage, unless otherwise designated as being cut for clean-up control. None of the plots are at the edge of the plantation but are surrounded by other trees which, of course, have an influence on these samples.

The plot shown in Table 6 is in a part of the plantation thinned to about 1100 trees per acre and pruned. The infestation remaining in 1930, after first control, was fairly light, and the year following even fewer attacks were found on these trees. The removal of one tree, which had been repeatedly attacked, the next winter reduced still further the infestation remaining in the plot in 1932. Only Scotch pine are considered in the per cent of infested trees. The average size of the Scotch pine in the plot in 1930 was 3.7 inches d.b.h., maximum 5.8 inches, and an average height of about 20 feet - the diameter measurements being taken with calipers and the heights estimated.

Table 6. - Plot 3A-S.P.3 one tenth acre of Scotch pine in a 1910 planting, thinned and pruned, showing amount of pitch moth infestation for three years following thinning and control cutting in the winter of 1929-30.

Year	No. of trees in plot	% of trees infested	Average no. attacks per infested tree	Infestation index
1930	112 (96 S.P.*	5.2	2.6	13.5
	(16 J.P.*	0	0	0
1931	112 (96 S.P.	4.2	2.5	10.5
	(16 J.P.	0	0	0
1932	111# (95 S.P.	2.1	1.5	3.2
	(16 J.P.	0	0	0

*(S. P. indicates Scotch pine; J. P. indicates Jack pine).

#(One infested Scotch pine cut in clean-up control in winter of 1931-32).

Another plot, somewhat similar in character to the one above except that the stand is a little heavier, is given in Table 7. Here again the infestation remaining in 1930 was low, however, the following year showed a considerable increase in number of attacks in contrast to the reduction in the first plot. The elimination of three heavily infested trees the next winter brought the 1932 infestation down to the 1930 level. Measurements on the Scotch pine in 1930 showed an average d.b.h. of 3.3 inches

with a maximum d.b.h. of 6.2 inches, and height averaging 20 feet.

Table 7. - Plot 30-S.P.; one tenth acre of Scotch pine in a 1910 planting, pruned but not thinned, showing amount of pitch moth infestation for three years following control cutting during winter of 1929-30.

Year	No. of trees in plot	% of trees infested	Average no. attacks per infested tree	Infestation index
1930	154 (145 S.P. 9 J.P.	3.4 0	3.0 0	10.2 0
1931	153 (144 S.P. 9 J.P.	6.9 0	3.2 0	22.1 0
1932	146*(139 S.P. 7 J.P.	4.3 0	2.5 0	10.8 0

*(Three heavily infested Scotch pine cut previous winter in clean-up; two additional with tops broken out also cut; two Jack pine dead)

A third plot, shown in Table 8, was established in this same plantation but in a portion left untouched for a check area - not thinned or pruned. No infestation occurred in the plot at the time and only about four trees showed evidence of older pitch moth work. The very dense stand was probably an important factor in lack of infestation, however, had the epidemic been heavier in this particular plantation attacked trees would undoubtedly have been found scattered through the plot as has been found in dense stands on badly damaged areas. This plot cannot be used for comparing the factor of original density with that of the thinned plots in Tables 6 and 7 because the original density and infestation in the latter is not known. However, the untouched plot now serves the purpose of comparing the annual amount of pitch moth work in the dense unpruned stand with that in the thinned and pruned plots in the same plantation. It is evident that there is as yet very little spread of the infestation into this dense stand. In size the trees are a little smaller than those in the thinned plots, the 270 Scotch pine, exclusive of the 13 Jack pine, averaged 2.8 inches d.b.h., maximum 5.7 inches, and about 19 feet tall in 1930.

Table 8. - Plot 3B-S.P.; one tenth acre plot in dense part of 1910 planting of Scotch pine not thinned and not pruned, showing amount of pitch moth infestation 1930-1932.

Year	No. of trees in plot	% of trees infested	Average no. attacks per infested tree	Infestation index
1930	(270 S.P. (13 J.P.	0 0	0 0	0 0
1931	(269 S.P. (13 J.P.	0 0	0 0	0 0
1932	(269 S.P. (13 J.P.	0.7* 0	1.5 0	1.1 0

*(One tree with two attacks in a Peridermium gall not counted).

Jack Pine

Records were taken in 1930 and 1931 on two Jack pine plots of 1/10 acre each, following the first thinning in an area planted in 1911 (Plantation P-50A) but there was not sufficient time to recheck these in 1932. The infestation was negligible so the summarized data will not be put in table form.

Plot 4B-J.P. had been thinned and pruned and contained 101 trees, 13 of which were ponderosa pine mixed in the stand. No infestation was found in the plot in 1930; in 1931 one attack was recorded on a Jack pine and one on a ponderosa pine.

Plot 4A-J.P. was the untouched control plot of 1/10 acre left unthinned in this plantation. The stand is dense, including 303 trees, only two of these trees being ponderosa pine. No pitch moth work was found in this plot in either 1930 or 1931. These plots indicate the small amount of infestation occurring in the denser stands of old Jack pine. In open stands infestation is more common.

REDUCTION IN INFESTATION FROM CONTROL CUTTING

It is apparent from the Scotch and Austrian pine plot data, given in Tables 3 and 4, that the control cutting in the winter of 1931-32 reduced

the pitch moth infestation considerably in these plantations. In the Scotch pine, Table 3, the number of attacks per 100 trees, indicated by the "Infestation Index" number, was reduced from 92.8 to 46.7 or a reduction of 50 per cent compared to the 1931 infestation. This, of course, does not take into consideration any increase from the 1931 flight of moths. In comparing the infestation in trees remaining on the plot in 1932 with the same trees the previous year, an increase of 33 per cent is indicated. With this increase the index number for 1932 would normally have been 123.5, and the actual reduction in infestation 62 per cent. This reduction was the result of removing a little over a half of all infested trees.

In the Austrian pine plot, Table 4, the "Infestation Index" in 1931 was 163.4 and following winter control cutting only 51.3 or a reduction of 69 per cent. Comparing the infestation in the uncut trees in 1932 with similar trees the previous year would indicate that a natural reduction might have occurred in 1932, but this may have been partly due to heavier concentration of attacks in the brood trees which were destroyed. Even if a small natural loss is considered it is estimated that the infestation in this Austrian pine was reduced 50 per cent as a result of cutting a third of the infested trees.

In the thinned plots of Scotch pine, Tables 6 and 7, where only a comparatively few trees were being attacked, the elimination of several of the worst trees in the clean-up operation in the winter of 1931-32 reduced the infestation from 33 to 50 per cent - assuming that no natural increase or decrease would have occurred.

INSECT PARASITES AND PREDATORS

Two Ichneumonid parasites and one Braconid parasite have been found attacking the one species of pitch moth, Dioryctria ponderosae, in the plantations; however, in most years they are of little importance.

Sesioplex new species, an internal, solitary, larval parasite, apparently attacks the maturing host larvae. The attacked larva is destroyed just before pupation and the parasite spins its heavy dark cocoon within the host cocoon in the pitch moth burrow. Emergence occurs from the middle of August to the middle of September. Parasitism by this species has been found to vary from 2 per cent to about 10 per cent in different years. In 1932, Scott estimated a 7 per cent parasitism, based on 160 host insects collected. This same species of parasite occurs in the native timber of northern Nebraska.

Amblyteles new species, a pupal parasite attacks the host during this stage in midsummer and emerges from the host pupal skin the following spring. This parasite is usually very scarce but it appears that in certain years it may be of some benefit. In 1929 out of only 28 pupae collected in the field about 20 per cent produced parasites the following spring. This amount of parasitism was perhaps a factor in the decreased amount of pitch moth infestation recorded in the Scotch pine plot in 1930. In 1930 out of 110 collected pupae only 3 were parasitized, or a parasitism of approximately 3 per cent. In 1931 not a single parasite larva was found in 152 collected host pupae - the unemerged pupae being dissected in early winter. No data are yet available on 1932 parasitism.

Microbracon rhyacioniae Muesebeck is more commonly a parasite of the pine tip moth, but in two cases in 1929 it was found on pitch moth larvae as an external, gregarious parasite. In one case 3 parasite grubs were observed feeding on the host larva, in the other case 4 grubs. The

adult parasites emerged on July 30 and August 1 with the exception of 1 male which remained in its cocoon until the following spring, emerging on May 10, 1930. It appears that only rarely does this parasite attack pitch moth larvae.

Up until 1932 no predacious insects had been observed attacking the pitch moths in the plantations. However, the past summer Scott found a Clerid beetle larva feeding on a pupa of Dioryctria ponderosae, in a pile of pitch moth infested logs cut and left in the shade. This larva has been identified by Dr. Boving as belonging to the genus Enoclerus. Scott also found several similar larvae under the bark of these same logs, but none of these additional specimens were connected with pitch moth burrows. It is probable that the Clerid beetles were attracted to these logs for oviposition because of the few bark beetles they contained. The chances of this predacious beetle developing to any extent on the pitch moth alone seem questionable. The food supply at any one point on the tree would be limited and, except in cases where a number of host larvae were working together, this might prove detrimental unless the beetle larvae are capable of moving over the surface of the bark to a new point of attack. None of these beetle larvae have yet been found in standing trees.

In native timber of northern Nebraska, in 1931, out of many trees examined only two cases were found where Clerid beetle larvae were feeding on pitch moth pupae. The larva of this beetle was identified as Cymatodera sp., consequently a different genus of Clerid than observed in the plantations. It is interesting to know that a predator of this type is present and it is possible that a small amount of benefit might result from its work.

WOODPECKERS

Woodpeckers have never taken up residence in the plantations of the Nebraska National Forest because of the lack of suitable nesting trees. However, it is known that both the hairy woodpecker, Dryobates villosus (Lin.) and the downy woodpecker, Dryobates pubescens medianus (Swain.), which normally feed to some extent on tree boring insects, occasionally pass through this area as migrants. There is a question as to whether these birds would prove to be an important factor in pitch moth control if suitable nests were provided and they could be induced to remain in the plantations. With a few bark beetles now present and the prevalence of pitch moth larvae, besides the native seeds and fruit, it seems that the food supply might be sufficient to maintain a few of these birds at least during the summer season. Although these woodpeckers are supposed to be permanent residents it appears that they have a local winter migration if food is not plentiful and consequently winter food supply might not be a factor in their establishment.

Regarding the pitch moth as food, there is no evidence available showing that the birds will extract the larvae from the pitchy burrows before the pitch has dried. Brunner in 1915 ("The Zimmerman Pine Moth", U.S.D.A. Bulletin 295, p.6) stated that the Rocky Mountain hairy woodpecker, Dryobates villosus monticola, destroyed many of the larvae of the Zimmerman pine moth in ponderosa pine in the northern Rocky Mountains. This insect is closely related and similar to the pitch moth in Nebraska, but it appears that most of this work occurred in early winter when many of the larvae were partially grown and at a time when there would be no flow of fresh pitch. He also mentions that the woodpeckers worked very little in the spike tops and in the knobby growth on the branches - apparently referring to Peridermium galls - and that considerable bark was stripped from the main bole of the trees. At

least it appears that the hairy woodpecker is not averse to feeding on pitch moth larvae under certain conditions. The life history of the common pitch moth, Dioryctris ponderosae, in Nebraska varies slightly from that of the above species and this might be of importance in woodpecker control. The insects pass the winter in the bark as very small larvae with little or no feeding until the following spring; therefore, it is doubtful if the birds could locate these larvae during the fall and winter, when most of the feeding cited above apparently took place. Only the developing larvae of the rather scarce species, Dioryctria abietella, would be noticeable at this period. It is possible that the only time when the prevalent pitch moth would be accessible and palatable would be in the mature larval and pupal stages during July and the first half of August, when most of the pitch in the burrows has dried. In native timber in north central Nebraska no woodpecker work has been observed in pitch moth trees, but these observations have been very limited.

Scott's discovery last summer, about the middle of August, of what was evidently a hairy woodpecker actually working on an infested Scotch pine in the plantations is of interest and indicates that this bird will attempt to seek out the pitch moths, at least in the pupal stage. Scott also found a few other trees where bark scales had been chipped off by a bird around pitch moth scars; however, in most of these cases the pupal cell had not been opened nor the pupa removed. This is the first evidence of woodpecker work being observed in the area.

There is other evidence that both species of woodpeckers pass through the forested area at times. In the latter half of August, 1931, the writer observed a lone woodpecker in the trees along the river by the nursery and this specimen was taken to be the hairy woodpecker, although its identity was not definite. In 1911 and 1912 Mr. John T. Zimmer, who was working out

the life history of the pine tip moth in the plantations of the Nebraska National Forest for the State Entomologist, made a comprehensive study of the bird fauna of the locality which he published in 1913 ("Birds of the Thomas County Forest Reserve", Proceedings of the Nebraska Ornithologists' Union, Vol. V, Part 5, April 14, 1913, 104 pp.). Regarding the hairy woodpecker, Zimmer's notes are as follows: "A pair of hairy woodpeckers was noted September 22, 1911, among the trees at the base of the hills, and on August 27 the following year I saw a single individual in the brush timber by the river. The Hairy Woodpecker, like most of the other woodpeckers which are found at Halsey, is a migrant and does not breed." He states the following in regard to the occurrence of the downy woodpecker, "A single Downey Woodpecker was observed across the river near the Reserve on August 29, 1912. R. H. Wolcott noted the species in July, 1908, but no other records are at hand of its occurrence at this locality, which is at about the western limit of distribution of the species in the State."

The matter of natural range will perhaps be a factor influencing the more common occurrence of one of these species of birds in the plantations. In discussing this question of woodpeckers several years ago with Dr. R. W. Dawson of the University of Minnesota, who is familiar with the Nebraska fauna, Dr. Dawson stated that the common downy woodpecker occurred in eastern Nebraska but that a variety of this species was found in the pine ridge country in the northwestern part of the State and, as is often the case, there is possibly a zone between the range of these two forms where both are scarce. The hairy woodpecker occurs in both sections of the State. It seems likely, therefore, as far as distribution is concerned that the hairy woodpecker is more apt to be a visitor in the plantations of the forest in central Nebraska than the other species. Brunner, in the first bulletin cited above, stated

that although woodpecker work on the Zimmerman pine moth was common in the Rocky Mountain region, bird work was entirely lacking in southeastern Montana on the northern Cheyenne Indian Reservation, and Custer National Forest. This may be another case of a zone of scarcity between the range of the common eastern hairy woodpecker and its Rocky Mountain variety.

In regard to nesting places for woodpeckers in the plantations, it would seem well worth while to construct or secure a number of properly constructed nesting boxes and place them at different locations in the worst pitch moth areas, in an attempt to induce these birds to take up residence. Of course, there are many environmental factors, besides the mere presence of a nest, that would influence the permanence of the woodpeckers, but the nesting boxes would be the first thing to provide. The boxes themselves should be of a particular design, resembling a natural woodpecker nesting cavity, with a gourd-shaped or pointed oval cavity and a lateral entrance hole of the proper size and sloping slightly upward. It is claimed that this type of nest has been used successfully in Europe to encourage the presence of woodpeckers in desirable areas. These nests should be constructed at least for the hairy woodpecker which it seems is more likely to come into the area. Or perhaps still better to provide boxes for both species, in which case cavities and entrance holes of different sizes would be essential. The proper size of these nests is not known and this information would have to be secured from some source before any construction is undertaken, unless it is found that this type of nesting box can be purchased.

CONTINUATION OF PITCH MOTH STUDIES

During the 1933 season, it is planned to follow up the effect of the winter control cutting operation on the pitch moth infestation. This will be mainly a recheck of the plots to determine the increase occurring from the flight of moths last summer. These moths are the product of the larvae remaining in the lightly infested, uncut trees. It is also planned to continue the spray experiments, starting this work earlier in the season. Other studies will depend on time available from other work on the Nebraska project and might include additional observations on the habits of early spring larvae, egg laying and incubation period, and habits of hibernation. The work of parasites and predators should also be followed. It would also be well to obtain some information on other species of pitch moths occurring in native timber of northern Nebraska but not yet present in the plantations, if this is at all possible.

Respectfully submitted,

L. G. Baumhofer,
Assistant Entomologist.

EXPLANATION OF PLATE I

Figure 1. Scotch pine partially girdled by pitch moth, broken in heavy wind on August 4, 1932. Tree 5.3 inches d.b.h., broken 4 feet from ground, pruned in winter of 1931-32. Depth of old pitch moth wound visible on surface of break. Fresh pitch masses visible on bark just above and at point of breakage.

Figure 2. Type of cage used in observing activities of pitch moth adults. Cage 3 feet square, with muslin top and bottom, and cheese cloth sides.

PLATE I

Fig. 1

Fig. 2

EXPLANATION OF PLATE II

Figure 3. Scotch pine cut for pitch moth control at edge of opening in a 1913 planting. The deformed condition apparent in these heavily infested "brood" trees is typical of damage caused by repeated pitch moth attacks.

Figure 4. A 1913 plantation (No. 70-2b) of Scotch pine thinned and pruned during the winter of 1931-32, showing a group of infested trees at the edge of the plantation cut for pitch moth control - other trees felled in the denser part of stand are not evident. This is the west end of Plot B-S.P., discussed with Table 3. (Photo taken August 7, 1932).

PLATE II

Fig. 3

Fig. 4